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Filter Element and Method for the Production Thereof

The invention relates to a filter element having a filter cylinder adjoining on its exterior a fluid-permeable support tube through which filter cylinder fluid to be filtered may flow and which is made up of a filter mat web which has a sequence of folds adjacent to each other at least in individual areas and the two ends of which are joined to each other at a connecting point in order to form an annular element. The invention also relates to a method for the production of such a filter element.

Filter elements of the type indicated in the foregoing are available on the market and are widely used, for example, in hydraulic assemblies in branches of a system through which hydraulic fluids flow. The known filter elements are not entirely satisfactory with respect to their safety in operation and the beta value stability of decisive importance for filter output. With high fluid outputs in particular, the danger exists that deformation or damage may occur at the junction point at which the ends of the filter mat web are joined to form the annular element forming the filter cylinder as a result of the differential pressure of the fluid which acts on the junction point. Such damage and/or deformation of the folds in the area of the junction point are here identified by the common expression Afold bulging.@

The object of the invention is to create a filter element characterized by operating safety and beta value stability which are better than those in the state of the art, even with high flow output.

In the case of one filter element of the type indicated in the foregoing, this object is attained by means of a configuration at the junction point acting to prevent a bulging of the folds in the area of the junction point caused by the action of fluid flow.

In that, as claimed for the invention, special protective measures have been taken at the point of junction of the filter mat web, which prevent bulging of the folds in this area, the desired improvement in operating safety is achieved even in the event of high flow output and correspondingly high fluid differential pressures in the area of the junction point.

In one preferred exemplary embodiment, the configuration preventing bulging in the area of the junction point is formed in that the folds of the filter mat web are joined to each other along those end edges, which face the interior of the annular element to be formed, so that both folds adjacent to each other at the junction point have their tops positioned on the exterior on the annular element and facing the support tube. In that the junction point, that is, the fusion seam or area of adhesion by means of which the annular element forming the filter cylinder is closed, is positioned in the interior on the filter cylinder, the junction point on both sides rests on the support tube by way of the adjacent folds, the tops of which are positioned on the exterior on the annular element. In this configuration the junction point forms no point weak in resisting the active forces resulting from the differential pressure applied in operation.

By preference, the filter mat web is in the form of a flexible mat structure of metal-free plastic-supported filter mats, connection of the ends of the filter mat web, so that a closed annular structure is formed, being effected by means of a fusion seam. In order to make simple

and efficient production possible, the fusing process must be carried out on the exterior of the annular element, that is, the junction point is positioned on the exterior of the filter cylinder so that, as stated earlier, the fusion seam would form a weak point of the filter cylinder during operation.

In order to make allowance for this factor, provision is made by the invention for an especially advantageous exemplary embodiment such that the dimensions determined for the flexible filter mat web are such that the annular element may be reversed after formation of an exterior fusion seam, so that the fusion seam is now positioned on the interior on the reversed annular element now ready for use.

Despite the simplicity of the production method, that is, formation of a fusion seam on the exterior, the annular element forming the filter cylinder after reversal is protected as desired from bulges in the area of the fusion seam now positioned in the interior.

In place of the protection from bulges resulting from the positioning of the junction point in the interior, or in addition to this protection, it is claimed for the invention that the configuration preventing bulging may have in the area of the junction point a retaining device with retaining elements which overlap the folds of the annular element adjoining the junction point on both sides, on the side of the folds facing away from the junction point. Especially secure support of the folds in the area of the junction point is thereby ensured.

The retaining elements of the retaining device may be in the form of a retaining projections formed on the inside of the support tube and projecting radially inward.

As an alternative, the retaining elements may be in the form of legs of a clamping element U-shaped in cross-section, which may be inserted onto the folds adjacent to the junction point of the annular element.

Another object of the invention is provision of a process for production of the filter element, the characteristics of this process being specified in claim 10.

The invention will be described in greater detail below with the aid of exemplary embodiments illustrated in the drawings in which:

- FIG. 1 shows a top view of an annular element provided for a filter element as claimed for the invention, in the partly completed state, a fusion seam formed on the annular element from the exterior being positioned on the exterior;

- FIG. 2 is a top view similar to that of FIG. 1, showing the annular element forming the filter cylinder in the finished state, that is, with the fusion seam positioned on the exterior after reversal;

- FIG. 3 is a perspective view of the annular element of FIG. 2;

- FIG. 4 is a perspective view of the filter disk formed in the course of reversal of the annular element shown in FIG. 1;

- FIG. 5 is a greatly enlarged representation of a fold section of the annular element, along with data indicating the dimensions;

- FIG. 6 is a cross-section of a second exemplary embodiment of the filter element claimed for the invention;

- FIG. 7 is a perspective view of the support tube of the exemplary embodiment shown in FIG. 6 less the filter cylinder present in this support tube, and

- FIG. 8 a perspective exploded view of a third exemplary embodiment of the filter element.

Reference is made to FIGS. 1 to 5, which illustrate a first exemplary embodiment of the filter element claimed for the invention, the conventionally configured support tube not being shown in these figures. When the filter cylinder is in the finished state, it is enclosed in this support tube, and is designated as a whole as 1, while in the form shown in FIGS. 2 and 3 it has been introduced into the support tube, which is not shown. During operation, filter fluid flows through the interior of the annular element indicated in FIGS. 2 and 3; that is, the clean side of the filter device (not shown) having the filter element claimed for the invention is situated on the exterior of the support tube enclosing the annular element 1.

As shown in the figures, the annular element 1 is in the form of a folded filter mat web, which is joined at its two ends to form a closed ring, the junction point being configured as a fusion seam 5. In the exemplary embodiments described here, the filter mat web is in the form of a flexible mat structure possessing resilient properties, more precisely in that of metal-free plastic- supported filter mats which may be fused together by a fusion seam 5 extending longitudinally to produce the annular element 1.

By preference a six-layer structure of the filter mat web is provided which has the following layers in sequence: an exterior support, a protective nonwoven layer, a prefilter layer, a main filter layer, a nonwoven support layer, and an interior support. A polyamide grid or a polyester fabric may be considered for the exterior support. A polyester material may be provided as the protective nonwoven layer. A glass fiber material, preferably in reduced form with respect to thickness and base weight, or a meltblown material may be considered for the filter layer. The main filter layer may analogously be a glass fiber material, which optionally is impregnated, or a meltblown material. A polyester or polyamide material may in turn be used as the support nonwoven layer, which may also be represented by a viscose nonwoven material or a

polyamide with meltblown material. The interior support may, like the exterior support, be configured as a grid or fabric based on a polyamide or polyester basis.

As is shown by comparison of FIGS. 1 to 4, this fusion seam 5 is displaced to the interior in the finished state shown in FIGS. 2 and 3 by reversal of the annular element 1 from the initial state illustrated in FIG. 1, in which the fusion seam 5 is positioned on the exterior, that is to say, is in the form of a lengthwise seam made on the outside. While in the state shown in FIG. 1, with fusion seam 5 positioned on the exterior, on the outer edge of the annular element 1, a gap 7 exists in the area of which there is no contact between the tops 11 of the folds 9 immediately adjacent to the fusion seam 5 on both sides and the enclosing support tube (not shown), in the state shown in FIGS. 2 and 3 the tops 11 of the folds 9 immediately adjacent to the fusion seam 5 are positioned on the outside (see FIG. 2) and accordingly are positioned adjacent on the support tube.

While in the case of the state shown in FIG. 1 there exists at the differential pressure prevailing during operation the danger of bulging in the area of the fusion seam 5, which may be moved radially outward by pressure forces, tensile forces being active on the fusion seam 5, which tend to tear the seam open, in the case of the reverse state illustrated in FIGS. 2 and 3, neither is bulging as a result of radial movement of the fusion seam 5 possible, since the adjacent fold top 11 is supported, nor is the fusion seam 5 subject to load application in the form of forces of pressure tending to effect separation.

FIGS. 4 and 5 serve to illustrate the configuration and determination of the dimensions of the filter mat web forming the annular element 1, that is, a configuration which permits reversal of the annular element. The maximum length of the annular element, which permits reversal if it is in the form of a flexible fold structure, depends on the number of folds, the height of the folds, the strength of the mat structure, and the thickness of the folds of the annular element. FIG. 4 illustrates the exterior and interior diameters of the disk element 13 which are temporarily

obtained in the course of reversal of the annular element 1. FIG. 5 illustrates determination of the dimensions of the folds 9 with respect both to strength of the material and to the fold size.

The maximum length of the annular element may be determined as follows on the basis of the parameters entered in FIGS. 4 and 5:

F_{ANZ}	= number of folds
F_H	= height of fold
F_D	= thickness of fold
M	= strength of material of mat structure
L_M	= extended length of filter web
L_{Mmax}	= maximum extended length of filter web
D_{amax}	= maximum external diameter of filter disk
D_i	= internal diameter of filter disk
L_{max}	= maximum length of filter cylinder

1) $L_M = 2^* F_{Anz} * \left(F_H - 2^* M + \frac{\pi^* M}{2} \right)$

2) $D_{a_{max}} = D_i + 2^* L_{max}$

3) $L_{max} = \frac{D_{a_{max}} - D_i}{2}$

4) $D_{f2} = \frac{F_{Anz} * F_D}{\pi}$

5) $L_{M_{max}} = D_{a_{max}} * \pi$

6) $D_{a_{max}} = \frac{L_{M_{max}}}{\pi}$

7) $D_{a_{max}} = D_i + 2 * L_{max}$

8) $L_{max} = \frac{D_{a_{max}} - D_i}{2}$

9) $L_{max} = \frac{\frac{L_{M_{max}}}{\pi} - D_i}{2}$ 8) mit6)

10) $L_{max} = \frac{L_{M_{max}} - F_{Anz} * F_D}{2 * \pi}$ 9) mit 4)

11) $L_{max} = \frac{F_{Anz} * \left(F_H - 2 * M + \frac{\pi * M}{2} - \frac{F_D}{2} \right)}{\pi}$ 10) mit 1)

[*mit* = with value of]

FIGS. 6 and 7 illustrate a second exemplary embodiment of the filter element claimed for the invention. Unlike the preceding example the support tube 15 enclosing the filter cylinder is shown, this support tube 15 being shown separately in FIG. 7, that is, without the filter cylinder inserted. As is clearly shown in FIG. 7, the support tube 15, which is of transfer-molded plastic, has on the exterior, which in a filter device as claimed for the invention adjoins the clean side, has strips 17 extending longitudinally which are connected by webs 19 forming annular elements between which are apertures 21 as fluid passages. As shown in FIG. 6, when a filter cylinder has been inserted into the support tube 15, the area adjacent to the fusion seam 5 on both sides is secured by a retaining device having retaining projections 23 and 25, which overlap the folds of

the annular element, which are adjacent to the fusion seam on both sides, on the sides of the folds facing away from the fusion seam 5 (see FIG. 6).

As shown in FIG. 7 in particular, the retaining projections 23 and 25 are integrally molded on the inside of the support tube 15 , a retaining projection 23 being configured to extend along and through a strip 17 of the support element, while divided retaining projections 25 are provided on the other side between which are interstices 27 corresponding to the apertures 21 forming the fluid passages. With the enclosure of the area of the fusion seam 5 formed by the retaining projections 23 and 25 effective protection is obtained from the danger of bulging in the area of the junction point.

FIG. 8 shows a third exemplary embodiment having a support tube 15 without interior retaining projections 23 and 25. In place of the enclosure of the area of the junction point, that is, the fusion seam 5, there is provided in this exemplary embodiment a retaining device having a metal clamping element 31 U-shaped in cross-section which may be positioned by way of insertion on the sides facing away from the fusion seam 5 and the retaining action essentially corresponds to that of the retaining projections 23 and 25 of the preceding exemplary embodiment.

In addition, in the example shown in FIG. 8, the annular element 1 has been reversed to assume the state shown in FIG. 2, so that the fusion seam 5 is positioned in the interior and the tops of the folds adjoining this seam are supported directly by the support tube 15. Consequently, this exemplary embodiment is protected in two ways from bulging in the area of the fusion seam 5.